

Final Report

**Revised Agricultural Emission Estimates
for the Houston-Galveston Nonattainment Area**

Prepared for

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INTRODUCTION

The purpose of this project was to prepare emission estimates from agricultural equipment usage using available survey information from the US Department of Agriculture's Census of Agriculture (USDA, 2002a). This survey provides estimates of the in-use equipment populations used for agriculture in each county of the US. This data provides an alternative source of information to compare with US EPA (1998 with recent updates in 2003) estimates.

Agricultural equipment emissions were a significant source of nonroad NO_x emissions, accounting for 10% of nonroad NO_x emissions, in the Houston-Galveston nonattainment area (HGA) State Implementation Plan (SIP) submitted to EPA in 2000. Accurately estimating the emissions from this source is important to determining if this source is important for air quality.

The agricultural category consists of the equipment types listed and described in Table 1. By far the most important equipment type is "agricultural tractors", primarily powered by diesel engines and accounting for over 80 percent of the THC, NO_x, and PM emissions from agricultural equipment. These agricultural equipment types are used primarily in agricultural production, yet the usefulness of agricultural tractors also extends to construction, landscaping (e.g. large scale mowing), and general-purpose grounds keeping.

Table 1. Equipment types and descriptions for agricultural equipment.
(xx refers to '60' for 2-stroke gasoline, '65' for 4-stroke gasoline, '70' for diesel, '67' for LPG, 68 for CNG).

| SCC | Equipment Type | Definition |
|------------|------------------------------|--|
| 22xx005010 | 2-Wheel Tractors | Walk-behind 2-wheeled tractors for use in edible produce or other intensive farming |
| 22xx005015 | Agricultural Tractors | Large and small agricultural tractors, most prevalent farm equipment type |
| 22xx005020 | Combines | Self-propelled combined harvesting and cleaning equipment |
| 22xx005025 | Balers | Equipment that bales from loose or windrowed hay or other forage mowed crop |
| 22xx005030 | Agricultural Mowers | Equipment for mowing not intended for later baling or harvesting |
| 22xx005035 | Sprayers | Small (backpack) and large (self-propelled) powered equipment designed specifically for spraying |
| 22xx005040 | Tillers > 6 HP | Primarily small tillers similar to those used in lawn and garden applications intended to be used in edible produce or other intensive farming |
| 22xx005045 | Swathers | Equipment designed to cut crops for later baling or harvesting including windrowers |
| 22xx005050 | Hydro Power Units | Power engines designed to specifically supply hydraulic power; might be misapplied as agricultural equipment |
| 22xx005055 | Other Agricultural Equipment | Other various cultivation equipment types and include harvesters or other special cultivating equipment |
| 22xx005060 | Irrigation Sets | Agricultural pumps and pivot wheel irrigation equipment to distribute water to fields or livestock. |

The Census of Agriculture and other information from the US Department of Agriculture (USDA, 2002) can be used to compare with the NONROAD default estimates of in-use equipment population. The population of equipment used on farms is regularly surveyed in the Census of Agriculture and the data include estimates of various types of farming equipment

by county and for agricultural tractors, delineated by three power level groupings. The US Department of Agriculture (USDA) conducts these periodic in-depth surveys of agriculture operations, which was last completed for the 1997 in-use equipment ownership. (Results of the 2002 survey are not expected to be available until 2004.)

The objective of this work was to compare the agricultural emission inventory for the Houston-Galveston nonattainment area (HGA consisting of the 8 counties surrounding Houston and Galveston) using the USDA data on agricultural equipment ownership with that of the just released version of the NONROAD model, NONROAD2002. (EPA, 2003) The latest version of NONROAD, available for use by state and local air quality planning agencies includes revised national equipment population estimates allocated to counties through the use of harvested acreage available from USDA estimates.

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RESULTS *(taken from end of report)*

Adjustments were made to the NONROAD2002 estimates of equipment population for tractors, combines, other agricultural equipment, and irrigation sets. This was accomplished by modifying eight population input files to reflect each county's equipment population totals within the HGA. The population totals for each equipment type were distributed across the fuel type (4-stroke or diesel primarily) and power levels (as shown below using the default information from NONROAD2002 for Texas diesel combines) using the NONROAD 2002 default distributions.

The information for agricultural tractors provided more delineation of power level where separate estimates were provided above 100 hp, below 40 hp, and between 40 and 100 hp. The equipment population was then distributed within the power-level groupings available to more accurately reflect the Census information.

The seasonal allocation was also modified to reflect the information collected in this study and described in Table 7.

The NONROAD2002 model was run for each of the eight HGA counties individually to compare the default estimates and those produced in this work. Annual and summer weekday and weekend day emission totals for 2000 and 2007 are shown in Tables 8 – 13. In general, much higher emissions are estimated using the Census of Agricultural figures because the equipment population estimates for agricultural tractors are much higher than the EPA default information.

Table 8. Year 2000 annual agricultural equipment emission totals (tpy).

| County | Revised Emissions | | | NONROAD 2002 Default Emissions | | |
|--------------|-------------------|------------|-------------|--------------------------------|------------|-------------|
| | Total NOx | Total VOC | Total CO | Total NOx | Total VOC | Total CO |
| Brazoria | 470 | 82 | 562 | 146 | 23 | 193 |
| Chambers | 154 | 25 | 178 | 70 | 11 | 92 |
| Fort Bend | 548 | 94 | 769 | 213 | 33 | 281 |
| Galveston | 141 | 25 | 181 | 14 | 2 | 19 |
| Harris | 392 | 72 | 452 | 99 | 15 | 131 |
| Liberty | 285 | 51 | 341 | 136 | 21 | 180 |
| Montgomery | 210 | 39 | 221 | 18 | 3 | 23 |
| Waller | 261 | 47 | 304 | 90 | 14 | 119 |
| TOTAL | 2461 | 436 | 3007 | 787 | 123 | 1038 |

Table 9. Year 2000 summer weekday agricultural equipment emission totals (tpd).

| County | Revised emissions | | | NONROAD 2002 Default emissions | | |
|--------------|-------------------|------------|-------------|--------------------------------|------------|------------|
| | Total NOx | Total VOC | Total CO | Total NOx | Total VOC | Total CO |
| Brazoria | 1.8 | 0.3 | 2.1 | 0.6 | 0.1 | 0.8 |
| Chambers | 0.6 | 0.1 | 0.7 | 0.3 | 0.0 | 0.4 |
| Fort Bend | 2.0 | 0.4 | 2.9 | 0.9 | 0.1 | 1.2 |
| Galveston | 0.5 | 0.1 | 0.7 | 0.1 | 0.0 | 0.1 |
| Harris | 1.5 | 0.3 | 1.7 | 0.4 | 0.1 | 0.6 |
| Liberty | 1.1 | 0.2 | 1.3 | 0.6 | 0.1 | 0.8 |
| Montgomery | 0.8 | 0.1 | 0.8 | 0.1 | 0.0 | 0.1 |
| Waller | 1.0 | 0.2 | 1.1 | 0.4 | 0.1 | 0.5 |
| TOTAL | 9.2 | 1.6 | 11.2 | 3.4 | 0.5 | 4.5 |

Table 10. Year 2000 summer weekend day agricultural equipment emission totals (tpd).

| County | Revised emissions | | | NONROAD 2002 Default emissions | | |
|--------------|-------------------|------------|------------|--------------------------------|------------|------------|
| | Total NOx | Total VOC | Total CO | Total NOx | Total VOC | Total CO |
| Brazoria | 0.9 | 0.2 | 1.0 | 0.3 | 0.0 | 0.4 |
| Chambers | 0.3 | 0.0 | 0.3 | 0.2 | 0.0 | 0.2 |
| Fort Bend | 1.0 | 0.2 | 1.4 | 0.5 | 0.1 | 0.6 |
| Galveston | 0.3 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| Harris | 0.7 | 0.1 | 0.8 | 0.2 | 0.0 | 0.3 |
| Liberty | 0.5 | 0.1 | 0.6 | 0.3 | 0.0 | 0.4 |
| Montgomery | 0.4 | 0.1 | 0.4 | 0.0 | 0.0 | 0.1 |
| Waller | 0.5 | 0.1 | 0.6 | 0.2 | 0.0 | 0.3 |
| TOTAL | 4.6 | 0.8 | 5.6 | 1.7 | 0.3 | 2.2 |

Table 11. Year 2007 annual agricultural equipment emission totals (tpy).

| County | Revised emissions | | | NONROAD 2002 Default emissions | | |
|------------|-------------------|-----------|----------|--------------------------------|-----------|----------|
| | Total NOx | Total VOC | Total CO | Total NOx | Total VOC | Total CO |
| Brazoria | 428 | 54 | 504 | 132 | 17 | 182 |
| Chambers | 140 | 17 | 160 | 63 | 8 | 87 |
| Fort Bend | 498 | 67 | 730 | 193 | 25 | 266 |
| Galveston | 127 | 16 | 164 | 13 | 2 | 18 |
| Harris | 357 | 46 | 391 | 90 | 11 | 123 |
| Liberty | 261 | 34 | 305 | 123 | 16 | 170 |
| Montgomery | 191 | 24 | 187 | 16 | 2 | 22 |
| Waller | 239 | 31 | 269 | 82 | 10 | 112 |
| TOTAL | 2242 | 289 | 2710 | 712 | 90 | 981 |

Table 12. Year 2007 summer weekday agricultural equipment emission totals (tpd).

| County | Revised emissions | | | NONROAD 2002 Default emissions | | |
|------------|-------------------|-----------|----------|--------------------------------|-----------|----------|
| | Total NOx | Total VOC | Total CO | Total NOx | Total VOC | Total CO |
| Brazoria | 1.6 | 0.2 | 1.9 | 0.6 | 0.1 | 0.8 |
| Chambers | 0.5 | 0.1 | 0.6 | 0.3 | 0.0 | 0.4 |
| Fort Bend | 1.9 | 0.2 | 2.7 | 0.8 | 0.1 | 1.1 |
| Galveston | 0.5 | 0.1 | 0.6 | 0.1 | 0.0 | 0.1 |
| Harris | 1.3 | 0.2 | 1.5 | 0.4 | 0.0 | 0.5 |
| Liberty | 1.0 | 0.1 | 1.1 | 0.5 | 0.1 | 0.7 |
| Montgomery | 0.7 | 0.1 | 0.7 | 0.1 | 0.0 | 0.1 |
| Waller | 0.9 | 0.1 | 1.0 | 0.4 | 0.0 | 0.5 |
| TOTAL | 8.4 | 1.1 | 10.1 | 3.1 | 0.4 | 4.2 |

Table 13. Year 2007 summer weekend day agricultural equipment emission totals (tpd).

| County | Revised emissions | | | NONROAD 2002 Default emissions | | |
|------------|-------------------|-----------|----------|--------------------------------|-----------|----------|
| | Total NOx | Total VOC | Total CO | Total NOx | Total VOC | Total CO |
| Brazoria | 0.9 | 0.1 | 1.4 | 0.3 | 0.0 | 0.4 |
| Chambers | 0.3 | 0.0 | 0.3 | 0.1 | 0.0 | 0.2 |
| Fort Bend | 0.9 | 0.1 | 1.4 | 0.4 | 0.1 | 0.6 |
| Galveston | 0.2 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| Harris | 0.7 | 0.1 | 0.7 | 0.2 | 0.0 | 0.3 |
| Liberty | 0.5 | 0.1 | 0.6 | 0.3 | 0.0 | 0.4 |
| Montgomery | 0.4 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| Waller | 0.4 | 0.1 | 0.5 | 0.2 | 0.0 | 0.2 |
| TOTAL | 4.3 | 0.6 | 5.5 | 1.5 | 0.2 | 2.1 |

Although the emission estimates of this work are higher than the NONROAD2002 defaults, they are lower than those used in the current SIP work for 2007 summer weekday: NOx emissions were estimated to be 12.9 tpd from MacKay (2000) vs. 8.4 tpd in this work. The current SIP estimates were derived from estimates prepared by EPA (1991); these were considered the official EPA estimate at the time of their use by TNRCC (2000). The older equipment population estimates were unadjusted estimates provided by Power Systems Research, a proprietary market research firm, which EPA has subsequently adjusted downward in their most recent release of the NONROAD model.

The equipment population estimates from the Census of Agriculture, however, may be incompatible with the activity estimates (hours per year) averages used in NONROAD2002. NONROAD2002 equipment population estimates may considered only those pieces of equipment that are active where the Census figures count all equipment types including those pieces of equipment that are rarely used. Further work should include a survey of the activity level, perhaps as part of the census, to adjust the NONROAD2002 activity estimates as well as the equipment population.

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